First draft. Comments welcome

Wage Inequality and Structural Reform: Evidence from Colombia[1]

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Abstract

This paper applies a simple two-factor framework that separates shifts in the relative supply of and demand for more educated workers. The results indicate that the decrease in the skill premium between 1976 and 1981 is related to the reduction in the relative demand for skilled workers, and the post-1991 increase in relative wages can be attributed to the rapid increase in their relative demand. Changes in relative supply are less helpful in explaining differences in relative wage behavior across periods. Moreover, the paper argues that trade liberalization is not the driving force behind changes in relative demand. In fact, changes in the share of skilled employment have taken place within industries, rather than involving a sharp sectorial reallocation of workers. We emphasize skill complementary technological change as the key factor behind changes in the relative demand. Further evidence in this direction is provided by the fact that the largest changes in the relative earnings of the more educated workers have taken place in the non-traded sectors.

[1] We would like to thank Juan Mauricio Ramírez for valuable suggestions. Financial support from the Banco de la República and Colciencias is gratefully acknowledged. The usual caveat applies.

1. Introduction

Colombia is a good case study for the analysis of the effects of structural reform on wage inequality. Between 1990 and 1994 the country adopted a comprehensive package of structural reforms. Average tariffs were lowered to 12% in 1992 from 40% in 1988 and free-trade agreements were signed with the Andean Pact countries, Mexico and Chile. The 1991 constitutional reform granted independence to the central bank. Also, controls on foreign exchange transactions and foreign direct investment were eliminated, and a fully funded private pension system was introduced. Most publicly owned financial institutions and large public utilities have been privatized.

As a result of the market-oriented reforms investment increased from 15% of GDP during the late 1980s to an average of 18% after reforms, mostly due to larger long-term foreign capital inflows, which doubled to nearly 5% of GDP per year. Investment in infrastructure is now 5% of GDP, nearly three times more its pre-reform level. Moreover, annual imports of capital goods increased from an average of US$1.2 billion (in constant 1996 dollars) between 1985 and 1991, to US$5 billion after the reforms[2].

At the same time, relative labor demand has shifted in favor of skilled workers causing an increase in overall wage differentials since 1991. As can be seen in Figure 1, wages of college graduates (16 or more years of schooling) relative to high school graduates (11 years of schooling) increased by 21% between 1991 and 1995. A similar result is obtained when earnings of college graduates are compared with those of workers with partial secondary or tertiary

[2] This increase in capital formation is consistent with the view that economic growth is higher on average in relatively more open economies (e.g., Edwards (1993), Sachs and Warner (1995) and Sala-i-Martin (1997)).

education. This increase in wage inequality contrasts with the rapid decline in educational wage differentials observed during the 1970s and early 1980s.

The purpose of this paper is to evaluate the causes of the early decline as well as the recent increase in wage inequality in Colombia. In particular, we relate changes in wage differentials to the gap between the rate of growth of the relative demand for more-skilled workers and the relative supply of such workers. Our results indicate that structural reforms increased the relative demand of skilled labor. As the rate of growth in relative supply was substantially smaller, the shift in demand resulted in greater relative wages. Similarly, this paper argues that the earlier reduction in wage differentials is related to the increase in the relative supply of relatively more-educated workers at a time when no major shifts in the relative demand were observed[3]. In sum, changes in educational wage differentials are primarily related to shifts in relative labor demand. Therefore, the paper also explores for the causes of changes in relative labor demand. The two leading explanations in the literature are trade competition and skill-biased technological change.

In relation to trade, standard theory predicts that liberalization increases the demand for workers in low value-added, labor intensive industries in countries that are relatively well endowed with unskilled labor. According to the Stolper-Salmueson theorem, liberalization should reduce the price of the factor of production that is relatively scarce or *scarce enough* (in the terminology of Leamer and Levinsohn [1995]).

[3] Revenga (1994), Feenstra and Hanson (1994), and Revenga and Montenegro (1995) have shown intriguingly similar trends for Mexico. Murphy and Welch (1991), Bound and Johnson (1992), Katz and Murphy (1992), Borjas and Ramey (1993a, 1994), and Lawrence and Slaugther (1993) analyze the recent decline in relative wages of less skilled workers in the U.S.

But this is not what happened in Colombia. As we mentioned, trade reform did not shift income towards the relatively abundant unskilled labor. In fact, the recent increase in relative demand for skilled labor is in line with the predictions of Davis (1996). He shows that if a country is capital (or skilled labor) abundant relative to the countries within its reference set (i.e., a group of countries with similar endowment proportions), the distributional consequences of liberalization will be the opposite to those of the conventional Stolper-Samuelson theorem. Indeed, we find that lower protection increases the relative earnings of the skilled workers.

Turning to the role of technological change, an increasing body of literature has pointed towards the role of skill-biased technical change as an explanation for greater wage dispersion and increases in the ratio of skilled to unskilled employment. In particular, Krueger (1993) has argued that computer technology is a factor that tends to raise the relative productivity of more skilled workers, lowering the demand for less skilled labor. In the case of Colombia, we find that investment in machinery and equipment in general, and in administration equipment (including computers) in particular, has a strong positive correlation with wage differentials.

This paper is structured as follows. Section 2 describes the main stylized facts on relative employment and relative wages in Colombia between 1974 and 1996. These facts are derived from two sources of information that are used throughout the paper. First, the Household Surveys (HS) which are available for every quarter since 1976 and cover the seven largest metropolitan areas. Second, the Manufacturing Surveys (MS) which are conducted on a yearly basis since 1974. Section 3 decomposes the relative demand for and supply of skills using a standard procedure. The results indicate that changes in relative demand have been larger that changes in relative supply during the 1990s. Section 4 explains relative demand shifts by separating the within and between-industry components of the growth in the proportion of skilled employment.

The results indicate that the former is always larger than the latter. That is, rather than sharp sectorial shifts, the increase in the share of skilled employment is consistently due to an increase in the employment of more educated workers within industries. Section 5 presents some econometric exercises on the determinants of wage differentials. The estimations are based on a panel of 4-digit manufacturing industries for the period 1974-1994. The results suggest that both trade liberalization and skill complementary technological change have a positive impact on skill premiums. The paper ends with a short section of conclusions.

2. Stylized Facts on Relative Wages and Employment

This section presents the stylized facts on wage inequality in Colombia, based on data derived from the quarterly Household Surveys (HS) and the annual Manufacturing Surveys (MS). In the case of the HS we use information for the wage earners only, which account for approximately 64 of the employed population. These surveys are plagued with methodological problems that have to be solved before an accurate measure of individual wage earnings is obtained. The main difficulties are related to top-coding problems in reported incomes, and to measurement errors on the part of the surveyors.

Top coding problems are present in most of the surveys. Until September 1993 the questionnaire allowed up to six digits for monthly incomes, so that higher end incomes were increasingly underestimated[4]. In fact, in June 1993 the number of truncated earnings represented 0.9% of the surveyed population. Since September 1993 seven digit incomes were allowed, but even then a fraction of the surveyed individuals reported the top coded income. It is only since

[4] At the 1993 exchange rate, the maximum allowed monthly income (Col$999.998) was equal to US$1,200.

March 1996 that the surveys no longer have limits on the maximum income reported. Several procedures can be used in order to correct for truncation problems. In this paper we use the methodology described in Bernal et al. (1997) which has better statistical properties than alternative procedures[5]. In addition, many workers report a weekly (or by-weekly) payment of their salary, but express their salary in monthly terms. Occasionally, the monthly salary has been wrongly multiplied by the frequency of payment. We solve this problem by excluding outliers within groups with similar socioeconomic characteristics.

Next, we need to define skill before measuring wage differentials. Much of the literature for industrial countries has used the *college premium* (as shown in Figure 1) as a measure of relative wages. This implies converting all workers into college and non-college workers, either by considering college graduates or college equivalents (usually college graduates plus half of those with some university). According to Figure 2, college graduates represented 11% of the employed population in 1995. In 1980, this share was only 5.5%. It seems inaccurate to restrict the number of more-educated workers to this small group. Alternatively, we use a measure of skill that includes college graduates plus all of those with some university education (all workers with 12 or more years of schooling). By using this definition, the group of more educated workers represented 23% of urban employment on average between 1992 and 1996. In this sense, our measure of relative wages should be called the *college equivalent premium* instead of the *college premium*.

Figure 3 shows the evolution of relative wages and relative employment (in bodies) for the more educated workers (12 or more years of schooling relative to the rest). The figure depicts

[5] The procedure is based on the estimation of the maximum level of income for the individuals whose incomes are truncated. Once that level is estimated an exponential function distributes the incomes of the truncated population.

these variables for total urban economy and for seven sectors: i. Manufacturing; ii. Electricity and gas; iii. Construction; iv. Retail, restaurants and hotels; v. Transportation and communications; vi. Financial services; and, vii. Personal and governmental services. The overall trends indicate a steady increase in relative employment, while relative wages decreased until the mid-1980s and have increased thereafter (especially since 1992). In spite of the recent increase, the wage gap between skilled and unskilled workers has been lower in the post reform period (1992-1996) than in the pre-reform years (1976-1991).

Interestingly enough, the sectorial data shows some differences. Relative employment of more educated workers in the manufacturing sector has fallen during the 1990s. As we will discuss later, the opposite result is obtained from the Manufacturing Surveys, which separate production and nonproduction manufacturing employment. However, relative wages have increased during the 1990s. A similar pattern is observed for relative employment and relative wages in the electricity sector, whereas in the construction sector there is evidence of a sharp increase in relative employment of more educated workers since 1990. There is no evidence of major increases in relative employment or relative wages after structural reforms in the retail sector, which generates 26% of the urban jobs. In contrast, sharp changes in relative employment and relative wages of more skilled workers is observed in transportation (6% of urban employment), financial services (7%) and personal and government services (30%). This means that much of the recent increase in wage differentials is related to changes occurring in the nontraded sectors of the economy.

Figure 4 plots relative wages against relative employment for each quarter from 1976 to 1996. The information is of interest because it suggests that the economy moved along a negatively sloped demand curve until the early 1990s. Since then, shifts in the relative demand

may have increased relative wages. In other words, continued changes in the relative supply may have resulted in lower relative wages until the mid-1980s. After the structural reforms of the early 1990s the reduction in the price of capital (and other factors) may have induced an increase in the relative demand for skilled labor, outpacing the increase in relative supply.

Indeed the relative supply has increased steadily since 1976. Figure 5 illustrates this point by showing the quarterly gross enrollment rates in primary, secondary, and tertiary education. As can be observed, greatest progress has been achieved in secondary education where enrollment rates rose by more than ten percentage points in nearly a decade. Enrollment rates in primary education as well as in university have increased significantly after reforms. As a result, the average schooling for the urban population increased by more than 3 years in two decades, more than what was observed in other Latin American countries.

We also use the Manufacturing Survey's annual data from 1974 until 1994. In this case, employment in bodies is available for production (blue-collar) and non-production (white-collar) workers. The use of relative nonproduction employment as a measure of skill has been questioned by Leamer (1994), who points out that skilled jobs such as line-supervisor, product development and record keeping are classified as production worker jobs while delivery, clerical, cafeteria and construction are classified as nonproduction. As mentioned, the nonproduction/production wage and employment ratios follow different trends compared to the ones reported above for the skilled/unskilled ratios in the manufacturing sector according to the household surveys[6].

[6] Berman, Bound, Machin (1997) find that in the case of the U.S. 75% of nonproduction workers are in white collar applications, while 81 of production workers are in blue collar occupations.

As can be seen in Figure 6, relative wages in manufacturing (nonproduction/production) have increased substantially since 1991. In fact, the wage differential between these two types of labor is nearly 20% higher than in 1990. Moreover, this differential had been declining steadily since 1974. Figure 7 displays relative employment and wages of nonproduction workers for 93 manufacturing sectors at the 4–digit level. There is evidence of an increase in both variables after reforms in almost all sectors.

In sum, as in the case of other Latin American countries, such as Chile and Mexico, trade liberalization in Colombia has coincided with increasing wage inequality[7]. In the rest of the paper we try to explain these trends by linking them to shifts in the relative demand of skilled workers. In turn, trade liberalization and the 'autonomous' introduction of new skill complementary technologies can explain these shifts. We start by looking at the relative demand of and supply for skills.

3. Relative Supply of and Demand for Skills

The previous section documented the rapid decline in the share of those workers with less than a high school degree during the 1976 – 1996 period. At the same time, the share of high school graduates with no additional education (11 years of schooling) has increased nearly three-fold, from 9% of the employed population in 1976 to almost 25% in 1996. Similarly, the share of college graduates has gone up from 5% in 1976 to 11% in 1996. This large increase in the supply of more-educated workers has been continuous and relatively stable. Despite this fact, relative wages have experienced sharp fluctuations during the past twenty years. Therefore, changes in

[7] For some international evidence see World Bank (1995, pp. 57-58).

relative demand must have played a pivotal role in the explanation of changes of educational wage differentials.

This section applies a simple two-factor framework that separates the relative supply and demand shifts. The methodology is taken from Autor et al. (1997) and assumes an inelastic short-run relative supply function and a downward sloping relative demand function. The point is that information on the relative wage bill of more educated workers and of changes in their relative wages can be used to draw inferences about the rate of growth in relative demand for and supply of skilled workers. In particular, using a simple CES technology with two factors, skilled (s) and unskilled labor (u), under the assumption that the economy operates on the labor demand curve, it must be true that relative supplies in year t (x_{st}/x_{ut}) and relative wages (w_{st}/w_{ut}), satisfy the following relationship:

$$\log(w_{st}/w_{ut}) = 1/\sigma\left[D_t - \log(x_{st}/x_{ut})\right] \qquad (1)$$

where σ is the aggregate elasticity of substitution between skilled and unskilled workers and D_t indexes the log relative demand shifts for skilled workers. Solving for D_t and rearranging terms:

$$D_t = \log(w_{st}x_{st}/w_{ut}x_{ut}) + (\sigma - 1)\log(w_{st}/w_{ut}) \qquad (2)$$

Table 1 summarizes the results based on the Household Surveys. Again, the exercise assumes that all workers with at least one year of college education are 'skilled'. That is, we group workers in two categories: less than 12 years of schooling (less educated), and 12 or more years of schooling (more educated). According to equation (2) changes in the log relative demand for skilled workers equal the change in the log relative wage bill and a term that depends positively (negatively) on the change in the log relative wage when the elasticity of substitution

(σ) is greater than one (smaller than one). If σ=1, then changes in the log relative demand for skilled workers are equal to changes in the log relative wage bill. There is little evidence on the elasticity of substitution between more educated and less educated workers in Colombia. Cárdenas and Gutiérrez (1996) provide an estimate based on production and nonproduction employment in the manufacturing sector. According to their results, this elasticity is close to one on average, although it has been increasing in recent years. Cárdenas and Bernal (1998) estimate this elasticity using sectorially disaggregated data from the household surveys. Their measurement ranges from 0.5 to 2.0, depending on the sector.

Panel A presents the information on the five year changes in the log relative wages and wage bill from 1976 to 1996. The log relative supply change is given by the log relative wage bill change minus the log relative wage change. The largest relative supply growth was observed from 1981 to 1991. Annual growth rates were 1.31% between 1981 and 1986, and 1.24% from 1986 to 1991. However, the behavior or relative wages was entirely different during this period, suggesting the presence of changes in relative demand. The rate of growth in the relative supply of skilled workers has decelerated during the 1990s.

Panel B measures the implied growth of the relative demand for skilled workers under different values of σ. According to this simple exercise, relative demand for skilled workers declined from 1976 to 1981. It then increased vigorously between 1981 and 1986, and then stabilized until 1991. The sharp increase in relative wages between 1991 and 1996 can be related to the deceleration of the rate of growth in relative supply and the acceleration of relative demand growth.

A somewhat different view is provided when the data from the Manufacturing Surveys is used instead. Panel A of Table 2 presents the changes in nonproduction/production log relative wages and wage bill. Panel B shows the implied relative demand shifts favoring nonproduction workers. According to this exercise, the acceleration in relative demand growth explains most of the difference in relative wage growth since 1976. This is of interest because relative supply has increased at very significant rates throughout this period. Indeed, between 1991 and 1996 relative supply grew at a rate of 6.3% per year. However, this impressive increase was insufficient to accommodate the larger growth in relative demand (12% per year).

In sum, relative demand shifts have played a central role in the determination of the skill premium during the last two decades. The decrease in the skill premium between 1976 and 1981 appears to be related to the reduction in the relative demand for more educated workers, and the post-1991 acceleration in the rate of growth in relative wages can be attributed to the rapid increase in relative demand. Changes in relative supply are less helpful in explaining differences in relative wage behavior across periods.

4. Empirical Evidence: Trade or technology, or both?

We now turn to the factors that could explain the shift in relative demand in favor of more-educated workers. The relative importance of trade and technology as a cause of growing income inequality is a matter of dispute. To take a few examples, using factor content analysis, Wood (1994 and 1995) argues that trade is the root cause of the fall in demand for less-skilled workers in advanced countries[8]. Borjas and Ramey (1994) reach a similar conclusion for the U.S.

[8] Leamer (1994) criticizes factor content calculations by arguing that in the Heckscher-Ohlin theory trade changes factor prices only if it changes product prices.

by finding a strong correlation between educational premia and the share of durable goods imports in GDP.

Alternative approaches have used price data on the goods produced by low-skill labor and information on skilled/unskilled employment in industries that produce traded and *nontraded* goods. If trade is the driving force behind changes in wage differentials then the decline in relative wages of unskilled workers implies a reduction in the relative price in low skill intensive industries. However, Lawrence and Slughter (1993) did not find evidence of a reduction in the relative prices of labor-intensive goods, while Sachs and Shatz (1994) found that prices of the least skill intensive sectors fell relative to the most skill intensive (after correcting for changes in total factor productivity) but not to the point of becoming a significant explanation of the increase in wage inequality[9]. In the case of studies that look also at nontraded sectors, Berman, Bound and Griliches (1992) show that the skilled/unskilled labor ratio increased in all U.S. sectors throughout the 1980s[10]. They argue that if trade was the driving force behind the reduction in the pay of unskilled workers in traded sectors, some nontraded sectors should have absorbed the displaced workers. Consequently, the skilled/unskilled labor ratio should have decreased (or at least remained constant) in some sectors. In sum, there is mixed evidence on the role of trade in explaining income inequality. According to the evidence for industrial countries, it is probably safe to conclude, along the lines of Freeman (1995) and Richardson (1995), that trade matters but that it is not the only force at play, and likely not the most important one.

[9] Wood (1995) argues that the reduction in the relative prices of unskilled labor-intensive goods found by Sachs and Shatz (1994) is consistent with observed changes in relative wages of unskilled labor.

[10] They support the 'technological' explanation of income inequality by finding that the sectors where computer investment is larger (as a proportion of total investment) also have the largest decline in pay to unskilled workers.

The argument that observed changes in intrasectoral skill intensities are due to new technology has been supported by various empirical studies surveyed in Mishel and Bernstein (1994). The standard result is that rises in the skill intensities of particular industries are positively correlated with measures of technology (e.g., capital stock, computer use, R&D expenditures, etc.)[11]. Krueger (1993) has argued that computer technology is a factor that tends to raise the relative productivity of more skilled workers, lowering the demand for less skilled labor[12]. More recently, Autor, Katz and Krueger (1997) have found that the acceleration in demand shifts for more skilled workers is entirely accounted for by an increase in within-industries changes in skill utilization rather than between-industry employment shifts. Industries with more pervasive computer usage show greater increases in skill intensity.

Critics have argued, however, that a common reaction to low-wage foreign competition has been the adoption of new technologies that economize unskilled labor. Thus, "defensive innovation" reduces the demand for unskilled labor in the import-affected sectors. Support for this argument has come from Lawrence and Slaughter (1993), Leamer (1994), and Sachs and Shatz (1994) who have found faster total factor productivity growth in low-skill than in high-skill sectors.

As the arguments of the previous paragraph make clear, in practice it is difficult to separate trade from technology as a cause of growing income inequality. Trade liberalization exerts additional pressure for firms to adopt new technologies and innovate more rapidly. It is likely that foreign competition has forced employers to adopt new technologies that save

[11] These correlations are derived from regressions that try to explain changes in the skill intensities across firms. However, when a trade related variable such as the rise in import penetration (Feenstra and Hanson [1994]) or export orientation (Bernard and Jensen [1994]) are added their coefficients are also statistically significant.
[12] See Bound and Johnson (1992) and Brauer and Hickok (1995) for a review of the evidence.

unskilled labor and induce shifts to high value-added production processes[13]. Trade and technology are intertwined forces, so in Wood's (1995) words "no story that excludes one or the other of them is likely to be the whole story".

The remainder of this paper looks at these issues using the Colombian data. This section presents the result of a decomposition exercise that tries to separate the within-industry and between-industry changes in relative labor demand. The next section presents some econometric results.

Shift-Share Analysis

The separation of the growth in the employment and wage bill share of more-educated workers (see Table A1 in the Appendix) into between-industry and within industries is useful in order to disentangle the relative importance of trade and technology as possible causes of the change in relative demand. If trade is the key factor, and assuming that Colombia is *locally* capital-abundant in the sense of Davis (1997), production and employment should shift from less-educated, import-intensive sectors to more-educated, export-intensive sectors. If skill complementary technological change is the driving force, the relative demand for skilled workers should increase within specific industries.

The decomposition of the change in the proportion of group s (skilled) workers (E_{st}) in aggregate employment (E_t) between years τ and t can be expressed as:

$$e_{st} - e_{s\tau} = \Delta e_{st} = \sum_k \Delta e_{kt} \overline{\alpha}_{sk} + \sum_k \Delta \alpha_{skt} \overline{e}_k \qquad (3)$$

[13] See Agénor and Aizenman (1996) for a model along these lines.

where $e_{st} = E_{st} / E_t$, $\alpha_{skt} = E_{skt} / E_{kt}$ is the group s share of employment in industry k at time t, $\bar{\alpha}_{sk} = (\alpha_{skt} + \alpha_{sk\tau})/2$, and $\bar{e}_k = (e_{kt} + e_{k\tau})/2$. The first term in (3) reflects the reallocation of employment across k sectors and the second term captures the change in the proportion of skilled employment within industries. An analogous decomposition can be done using skill labor shares in the wage bill instead of employment shares.

Table 3 presents the results using the HS. Again, in this case s corresponds to workers with 12 or more years of schooling and k denotes seven urban sectors of production. Table 4 reports the shift-share analysis for the manufacturing sector. In this case the data come from the Manufaturing Surveys where s is nonproduction labor and there are 93 sectors (according to the four-digit CIIU classification).

Interestingly enough, the within-industry component of the growth in the proportion of skilled employment is always larger than the between-industry component. In fact, the path of the share of skilled employment is entirely related to the growth in the within industry component. That is, rather than sharp sectorial shifts, the increase in the share of skilled employment is consistently due to an increase in the employment of more educated workers within industries. A similar pattern is observed for the shares of skilled workers in the wage bill. Finally, the pace of within-sector skill-upgrading does not seem to have changed substantially during the 1990s, relative to other periods.

This evidence implies that trade liberalization did not contract the unskilled labor-intensive sectors, a result that would have been expected if Colombia protected its labor intensive sectors prior to the trade reform. As shown in Figure 8, there is not a significant correlation between skill intensity and nominal tariff protection, neither before nor after reform. Moreover,

tariff declines in manufacturing do not seem to be correlated with skill intensities prior to the reform. In contrast, Hanson and Harrison (1997) and Currie and Harrison (1997) find that protection was significantly higher in sectors with a higher share of unskilled workers in Mexico and Morocco, respectively.

5. Econometric Evidence

This section presents the results the regression estimates of the log of relative wages (nonproduction/production) using a panel of 93 4-digit manufacturing sectors for the period 1978-1994. In particular, we estimate the following equation:

$$\omega_{it} = a_0 + \alpha k_{it} + \beta y_{it} + \gamma \tau_{it} + \varepsilon_{it}, \qquad (4)$$

where i denotes sectors and t the year, ω is the log of the relative wage, k is a measure of skill biased technological progress, y is production, and τ is the nominal tariff. In turn, the error term can be decomposed into:

$$\varepsilon_{it} = f_i + \delta_t + \mu_{st}, \qquad (5)$$

where f_i is the sector-specific component, δ_t is the time-specific component, and μ_{it} is an i.i.d. error; f_i captures the unobserved characteristics that are specific to each sector which are time invariant and δ_t captures the shocks that are common to all sectors at each point in time. OLS can be used if the intercept and the error ε_{it} are common to all sectors. If the intercept is sector-specific it is necessary to introduce the term f_i in the equation. In this case it is necessary to use fixed effects by adding a dummy variable for each sector.

Table 5 shows the basic results of an equation that includes overall net investment, investment in machinery and equipment, investment in administration equipment, production, and nominal protection as regressors. The null hypothesis of common intercepts can be rejected a high levels of confidence so fixed effects are used[14]. The results are straightforward and indicate that investment (as a percentage of production) increases relative wages of nonproduction workers. The reason is that new technologies are embodied in capital goods that are skill complementary. Thus, investment raises the relative demand for more-educated workers and increases their relative wages. The effect is quantitatively larger for investment in administrative equipment, which includes computers. In fact, a one-percentage point increase in this type of investment (as a share of total production) increases relative wages by 18%.

The elasticity of relative wages with respect to production is positive and statistically significant. This means that when production increases, the demand for skilled labor increases more than proportionally. Nominal protection is negatively and significantly correlated with wage differentials. Relatively more protected sectors have lower relative wages. Finally, the dummy variable for the post-reform period indicates that, on average, relative wages have been 14% higher since 1992 as a result of other factors excluded in the regression.

In the regressions reported in Table 6 the explanatory variables have been interacted with dummy for the post-reform period. The results indicate that trade liberalization marginally reduced the semi-elasticities of relative wages with respect to investment in administration equipment and with respect to nominal protection (in absolute terms). The elasticity with respect to production slightly increased. This means that the effects of reform came through greater

[14] See Judge et al. (1988), p. 475.

investment and lower tariffs and not by increasing the responsiveness of wage differentials to these variables.

6. Conclusions

This paper has analyzed the changes in wage inequality in Colombia since 1976. The evidence presented indicates that wage dispersion has increased since the early 1990s. Wages of more-educated workers rose in relation to all other educational categories. In the manufacturing sector, wages of nonproduction or white-collar workers increased in relation to production or blue-collar workers. The paper argues that changes in relative wages are mainly the result of shifts in the relative demand for skilled workers.

In turn, the evidence presented suggests that skill complementary technological change has been a key force behind the recent increase in the relative demand for more-educated workers. Much of the change in skill intensity has taken place within specific industries, rather than involving large reallocations between sectors. Trade reform has not resulted in a greater expansion of skill intensive sectors relative to unskilled intensive sectors. Quite the contrary, trade liberalization and other reforms that lowered the user cost of capital and relaxed liquidity constraints, facilitated investment in skill complementary technologies within all sectors of production. Further evidence in this direction is provided by the fact that the largest increases in the relative earnings of the more educated workers took place in the non-traded sectors.

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Table 1

Skilled and unskilled workers wage-bill shares, supply and demand shifts 1976-1996

A. Changes in relative wages, wage bill and supply for more educated workers (100*annual log changes)			
	Relative wage	Relative wage bill	Relative supply change
1976 - 1981	-1.67	-0.79	0.88
1981 - 1986	-0.52	1.82	1.31
1986 - 1991	-0.51	0.72	1.24
1991 - 1996	0.89	1.61	0.72

B. Implied relative demand shifts favoring more educated workers				
	$\sigma = 0.5$	$\sigma = 1$	$\sigma = 1.5$	$\sigma = 2$
1976 - 1981	0.04	-0.79	-1.62	-2.46
1981 - 1986	1.57	1.82	2.08	2.33
1986 - 1991	0.98	0.72	0.46	0.21
1991 - 1996	1.16	1.61	2.05	2.50

Source: National Household Survey and own calculations

Table 2

Non production and production workers wage-bill shares, supply and demand shifts in the manufacturing sector, 1974-1994

A. Changes in nonproduction to production relative wages, wage bill and supply (100*annual log changes)			
	Relative wage	Relative wage bill	Relative supply change
1976 - 1981	-2.63	-0.71	1.92
1981 - 1986	-1.45	1.72	3.17
1986 - 1991	1.54	4.10	2.55
1991 - 1996	6.10	12.37	6.27

B. Implied relative demand shifts favoring nonproduction workers				
	$\sigma = 0.5$	$\sigma = 1$	$\sigma = 1.5$	$\sigma = 2$
1976 - 1981	0.61	-0.71	-2.02	-3.33
1981 - 1986	2.45	1.72	1.00	0.27
1986 - 1991	3.33	4.10	4.87	5.64
1991 - 1996	9.32	12.37	15.42	18.47

Source: Annual Manufacturing Survey and own calculations

Table 3

Between and Within Sector Decomposition of the Increase in the Share of Workers with 12 or More Years of Schooling in Employment

A. Employment			
	Between	Within	Total
1976 - 1981	0.27	2.12	2.38
1981 - 1986	-0.29	4.04	3.75
1986 - 1991	0.26	3.96	4.23
1991 - 1996	0.90	1.78	2.69
B. Wage Bill			
	Between	Within	Total
1976 - 1981	-0.96	-2.54	-3.50
1981 - 1986	1.00	6.96	7.96
1986 - 1991	-0.49	4.09	3.60
1991 - 1996	2.11	5.90	8.00

Source: National Household Survey and own calculations

Table 4

Between and Within Industry Decomposition of the Increase in the Share of Nonproduction Workers in Employment, 1976-1996

A. Employment			
	Between	Within	Total
1974 - 1981	0.63	1.96	2.59
1981 - 1986	0.22	3.04	3.26
1986 - 1991	0.18	2.59	2.77
1991 - 1994	0.48	3.81	4.30
B. Wage Bill			
	Between	Within	Total
1974 - 1981	0.68	-1.89	-1.20
1981 - 1986	0.61	1.49	2.10
1986 - 1991	0.24	4.84	5.09
1991 - 1994	0.95	8.26	9.21

Source: Annual Manufacturing Survey and own calculations

Table 5

Industrial Panel Estimations (Levels)
1978-1994

	Eq. (1)	Eq. (2)	Eq. (3)
Dependent variable-> Log(Relative wages)			
Constant			
Dummy 92-94	0.1400 (9.73) ***	0.1402 (9.74) **	0.1387 (9.62) ***
Total net investment*	0.0068 (1.96) **		
Investment in machinery and equipment*		0.0080 (1.85) **	
Investment in administration equipment *			0.1814 (2.14) **
Log (Production)	0.0492 (5.73) ***	0.0489 5.7 **	0.0508 (5.80) ***
Nominal tariff	-0.1724 (-4.14) ***	-0.1724 (-4.13) **	-0.1724 (-4.13) ***
R^2	0.5356	0.5355	0.5359
F - "fixed effects" [H_0: $a_i = a$]	12.960	12.96	12.9700
P-value	(0.00)	(0.00)	(0.00)
Number of observations	1479	1479	1479

* As percentage of production
Estimated by OLS

Source: Annual Manufacturing Survey (4-digit classification). Own calculations.

Table 6

Panel Estimations: Manufacturing Sector 1978-1994

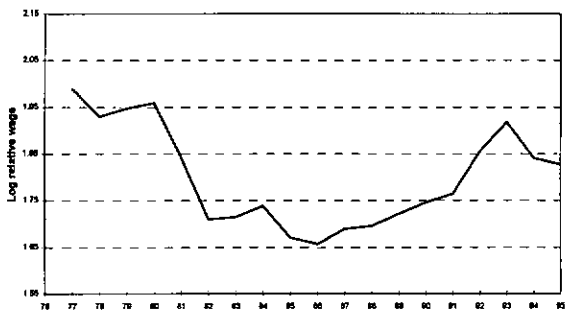
	Eq. (1)	Eq. (2)	Eq. (3)
Dependent variable-> Log(Relative wages)			
Constant			
Total net investment*	7.E-05 (1.99) **		
Total net investment*dum92-94	-3.E-04 (-0.46)		
Investment in machinery and equipment*		0.0083 (1.92) **	
Invest. in machinery and equipment *dum92-94		-9.E-05 (-0.90)	
Investment in administration equipment			0.1884 (2.22) **
Invest. in administration equipment * dum92-94			-0.0149 (-1.91) **
Log (Production)	0.0498 (5.68) ***	0.0499 (5.72) **	0.5023 (5.65) ***
Log (Production) * dum92-94	0.0040 (1.60) *	0.0038 (1.52)	0.0046 (1.82) *
Nominal tariff	-0.1700 (-4.17) ***	-0.1765 (-4.13) **	-0.1788 (-4.21) ***
Nominal tariff * dum92-94	0.0053 (2.07) **	0.0053 (2.07) **	0.0053 (2.05) **
R^2	0.5317	0.5315	0.5332
F - "fixed effects" [H_0: $a_i = a$]	12.810	12.80	12.89
P-value	(0.00)	(0.00)	(0.00)
Number of observations	1479	1479	1479

* As percentage of production
Estimated by OLS

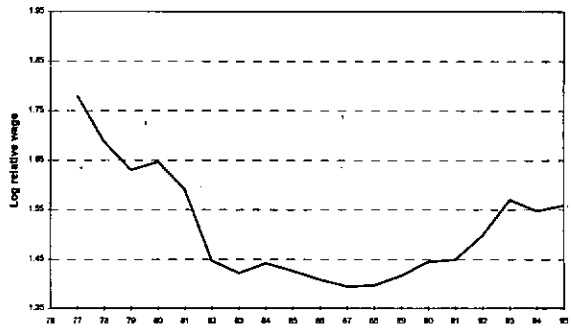
Source: Annual Manufacturing Survey (4-digit classification). Own calculations.

Figure 1
College Premium: Log of relative wages for workers with 16 or more years of schooling

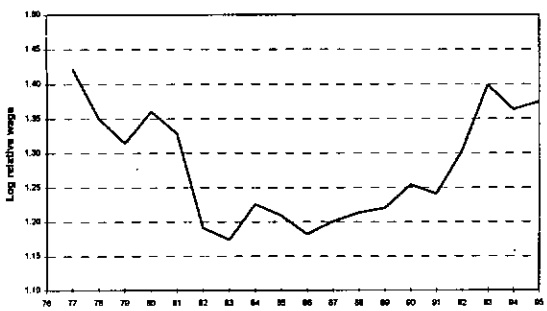
A. 16+ / 0



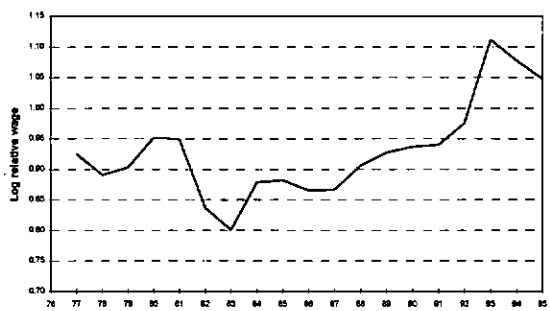
B. 16+ / 1-5



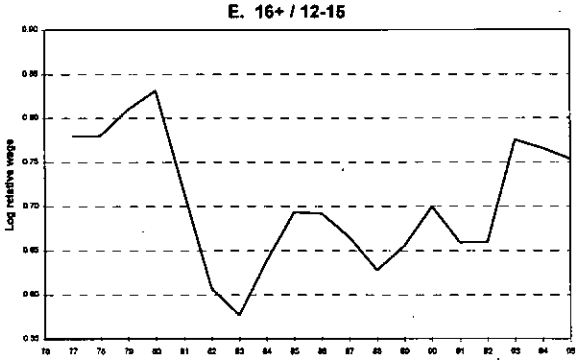
C. 16+ / 6-10



D. 16+ / 11



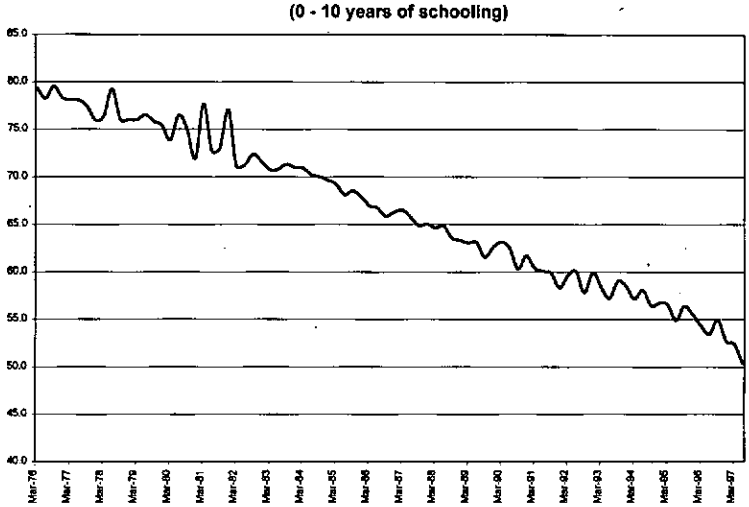
E. 16+ / 12-15



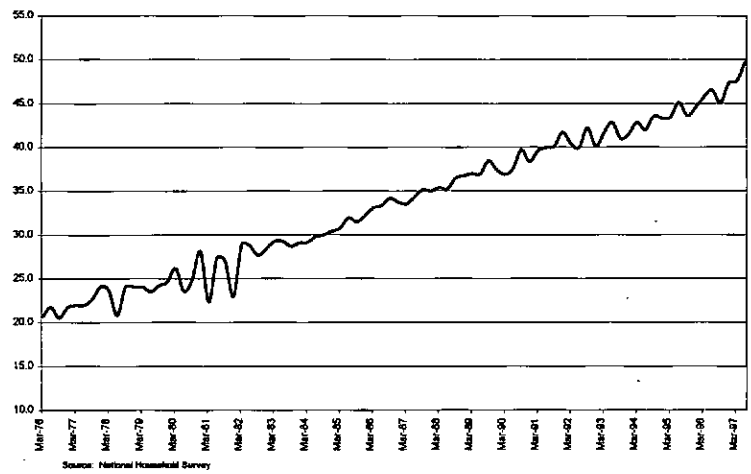
Source: Sánchez and Núñez (1988) based on the National Household Survey.

Figure 2
Employment Shares

A. Workers with less than completed high school
(0 - 10 years of schooling)



B. Workers with completed high school or more
(11 or more years of schooling)



Source: National Household Survey

C. Workers with some post-secondary education
(12 or more years of schooling)

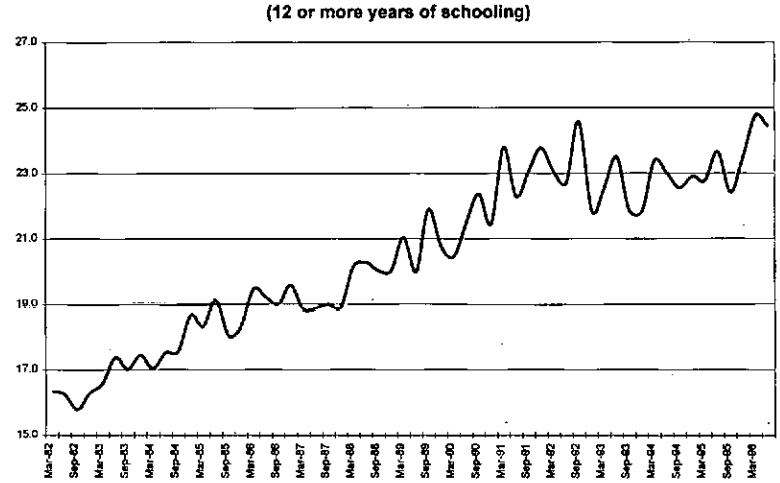
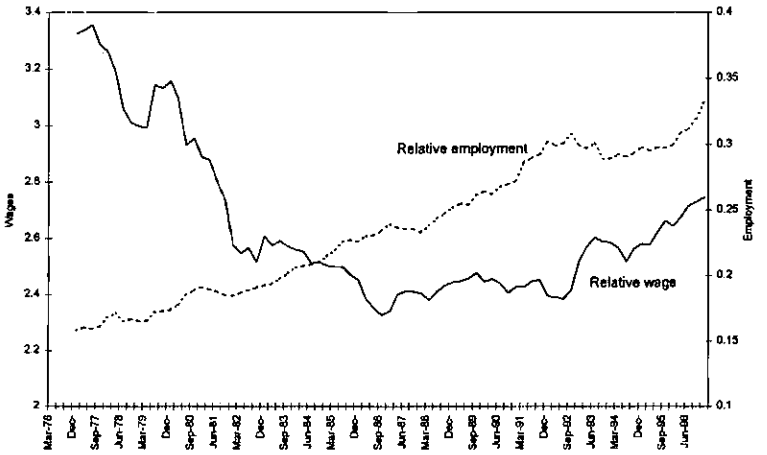
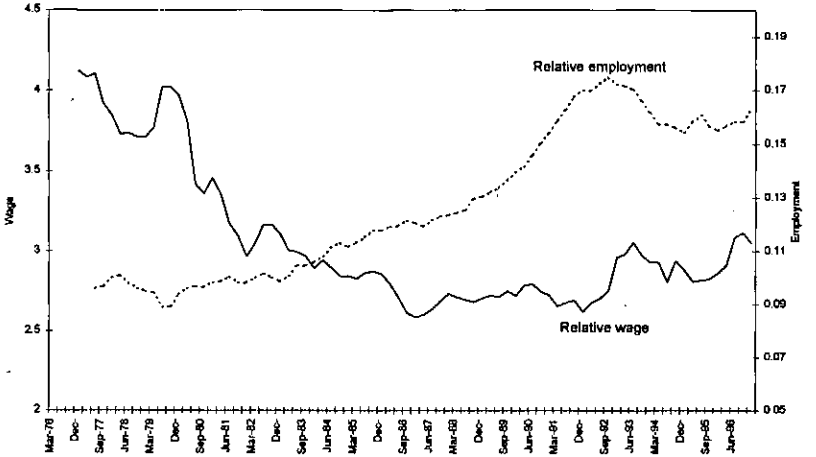


Figure 3
Relative wages and relative employment
(12 years or more of schooling / less than 12 years of schooling)

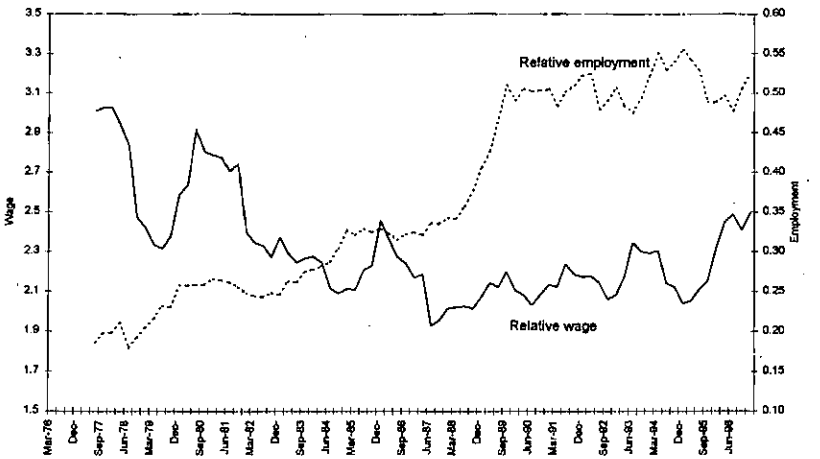
A. Total



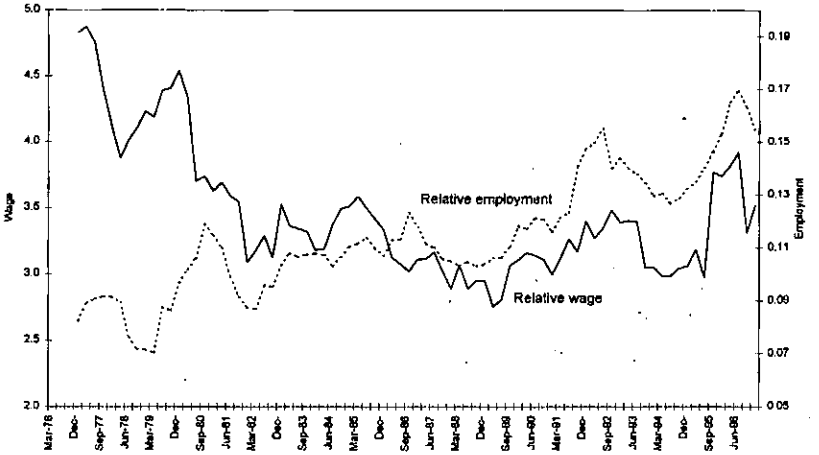
B. Manufacturing



C. Electricity



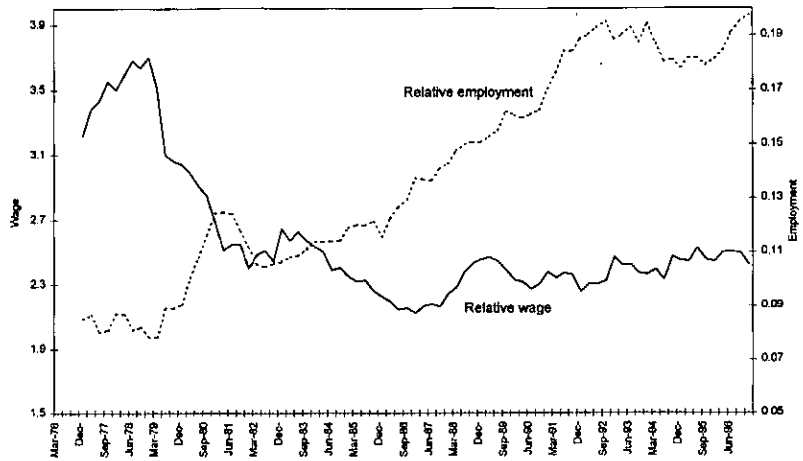
D. Construction



Employment in bodies and average monthly wages.

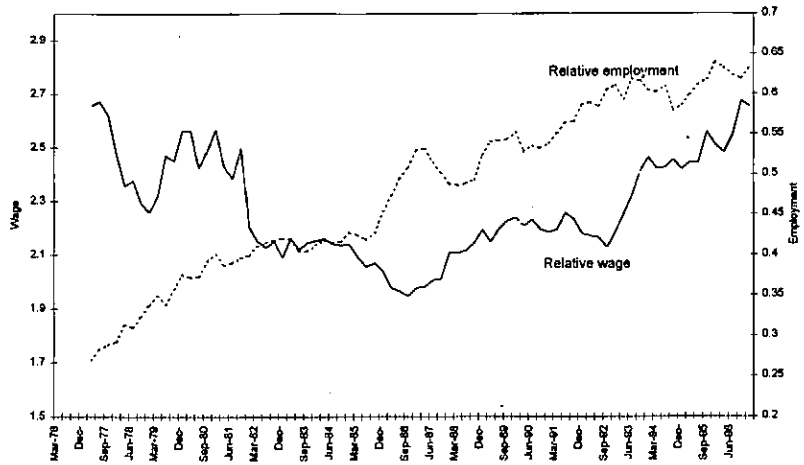
Figure 3 (cont.)

E. Retail



F. Transportation

G. Financial Services



H. Personal and Governmental Services

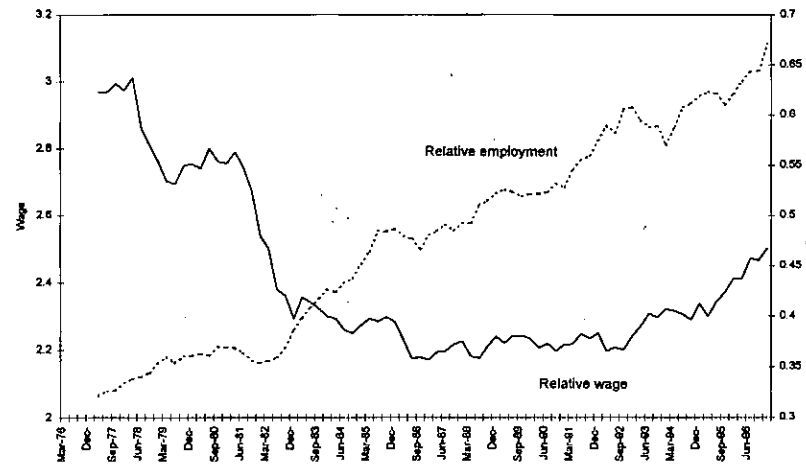
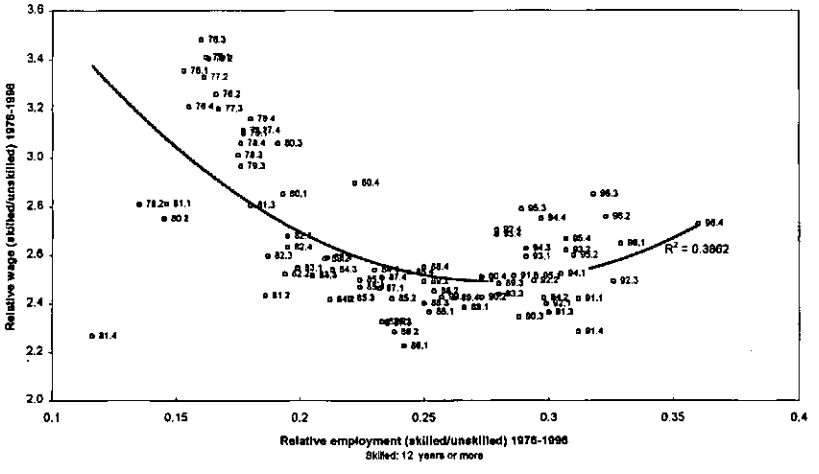
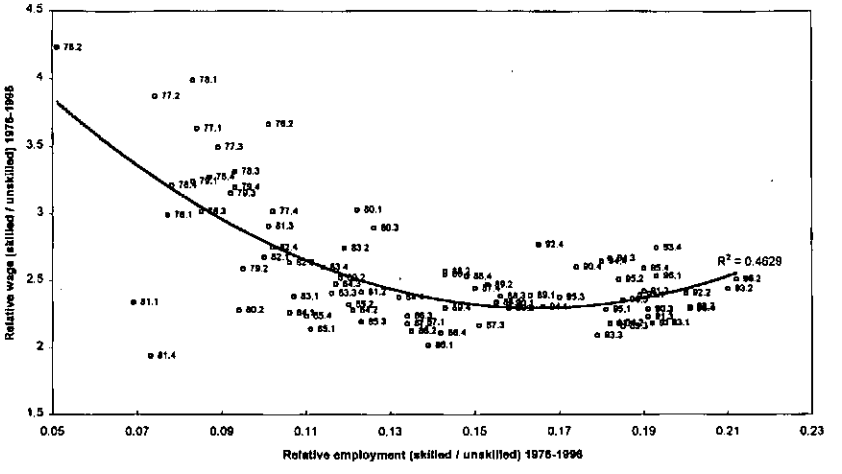


Figure 4
Relative wages and employment

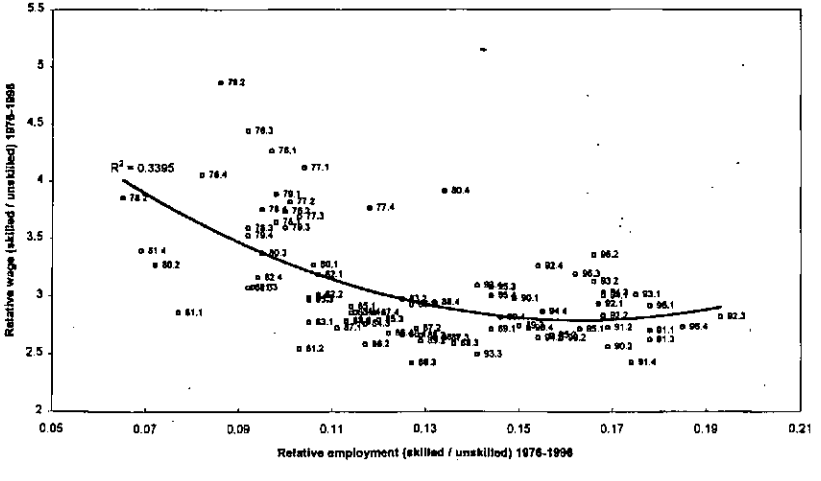
A. Total



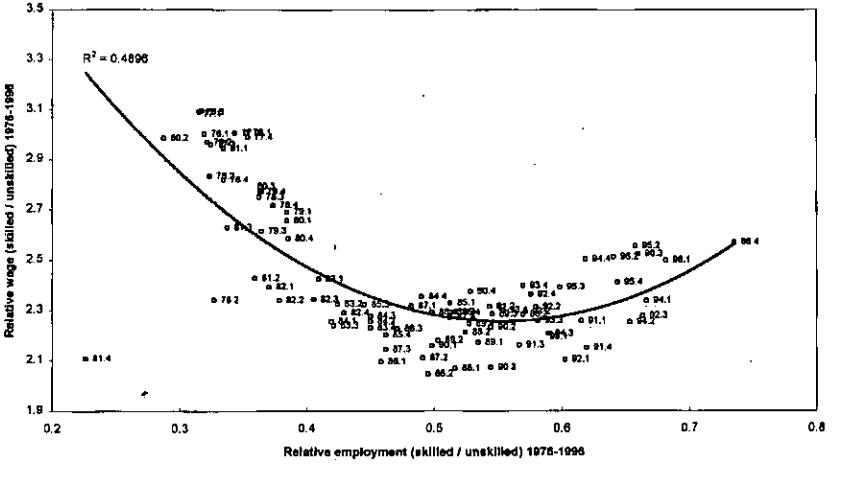
B. Retail



C. Manufacturing



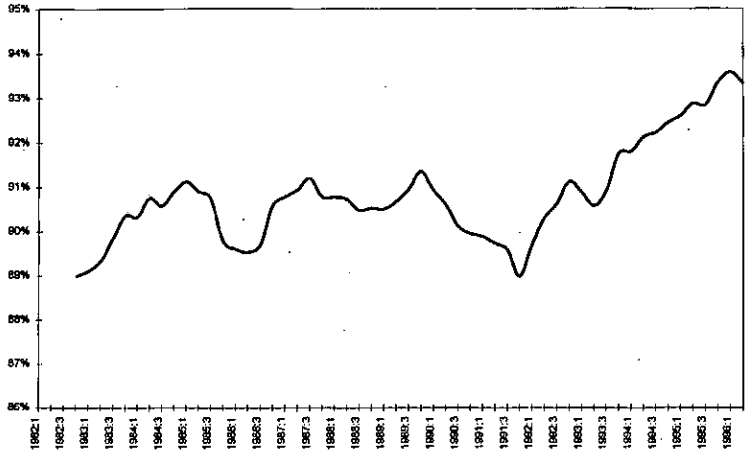
D. Services



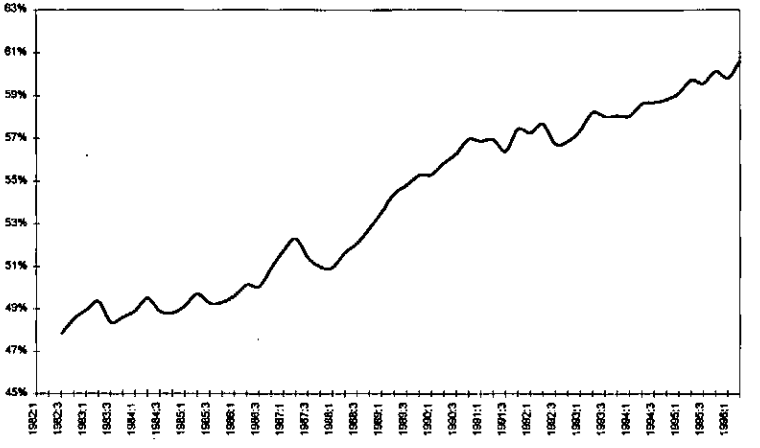
Employment in bodies and average monthly wages

Figure 5
Education: Enrollment Rates and Average years of Schooling

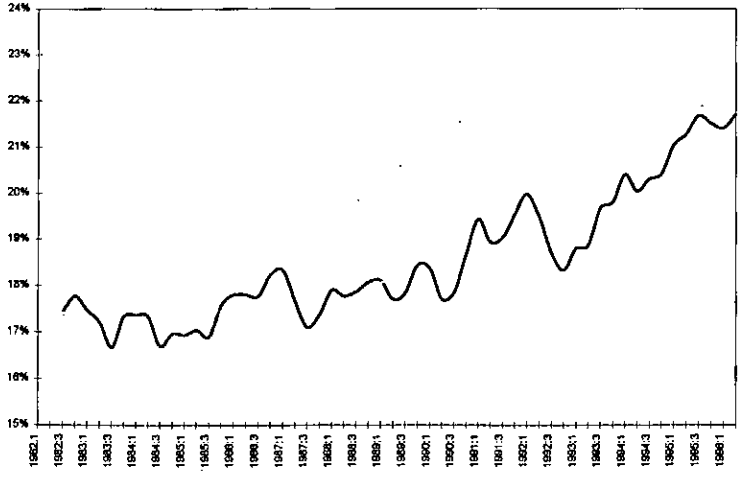
A. Primary



B. Secondary



C. University



D. Average years of schooling

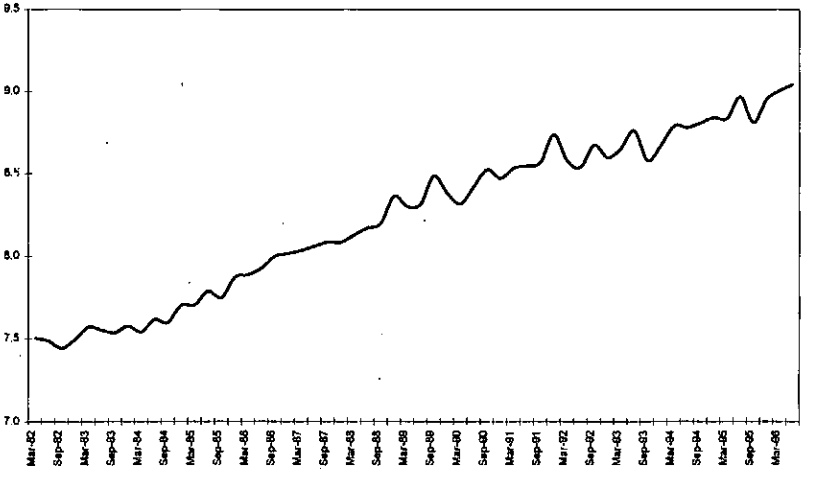
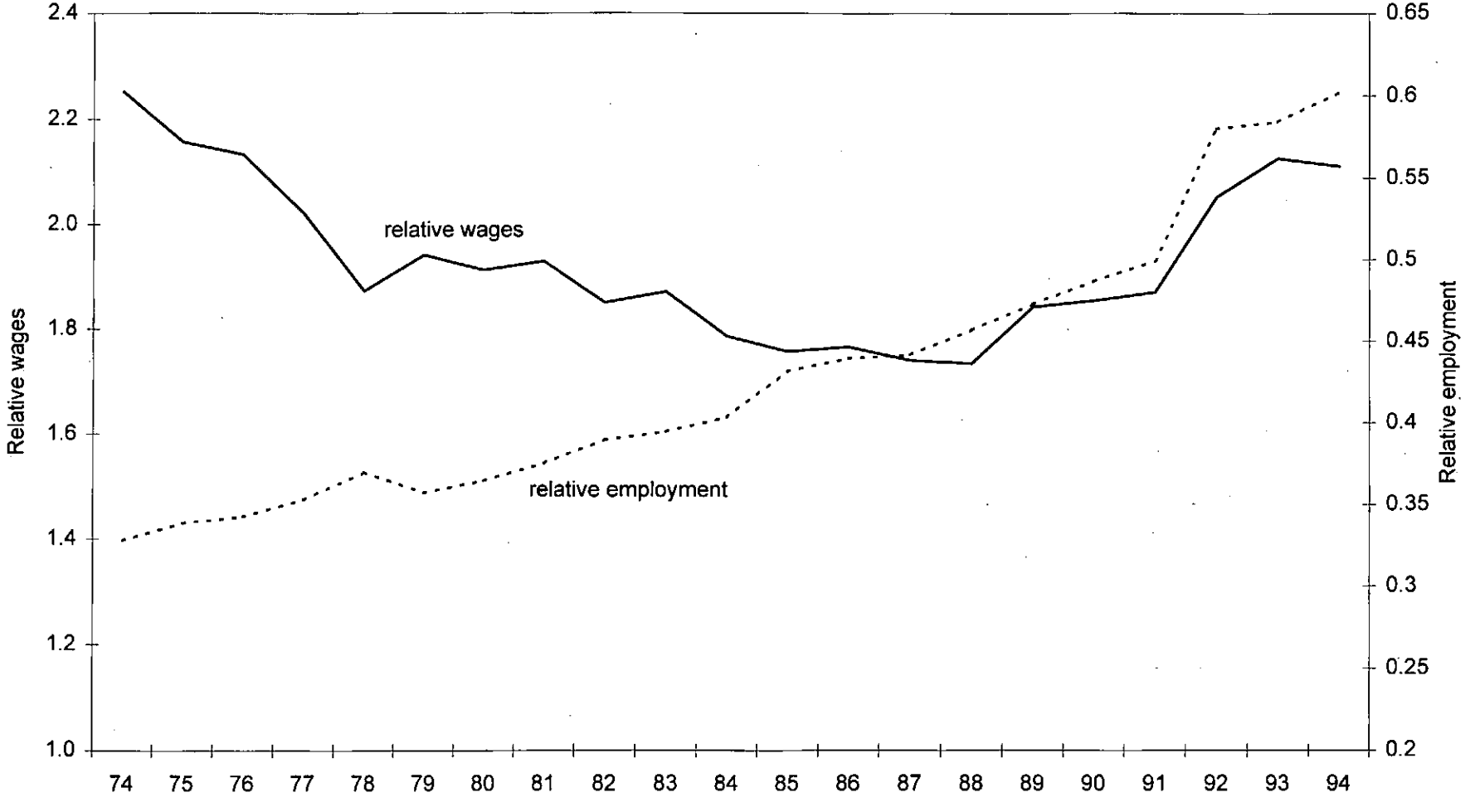


Figure 6

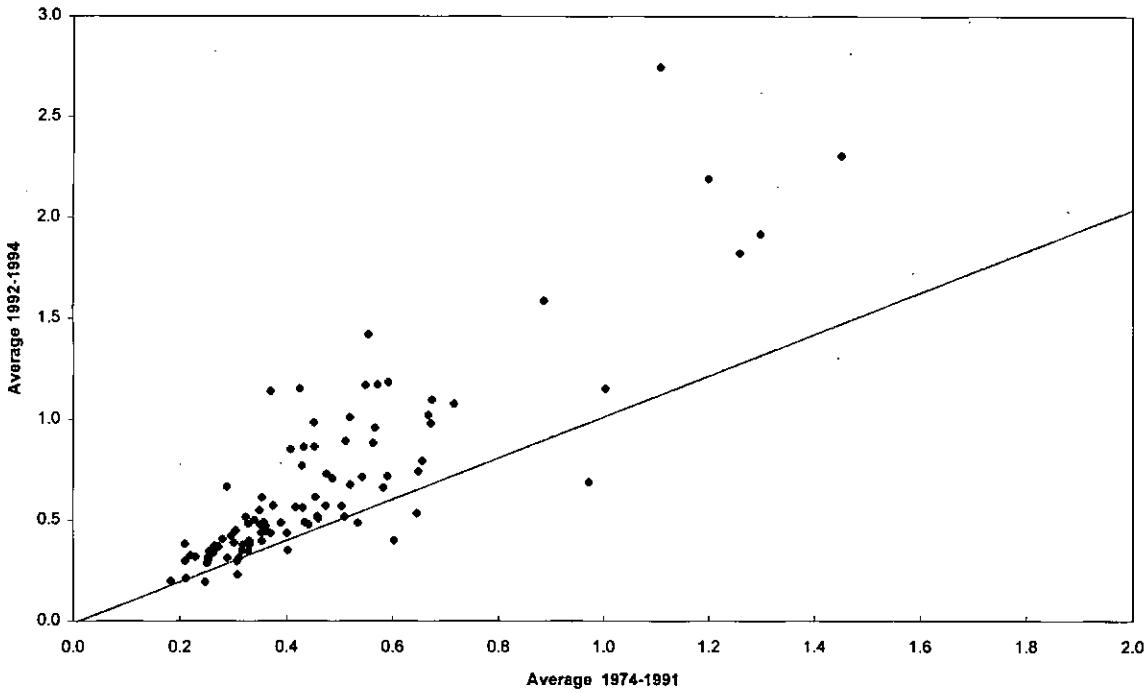
Relative employment and wages in the manufacturing sector
(non production / production workers)



Source: Annual Manufacturing Survey

Figure 7

A. Relative employment
(nonproduction / production workers)



B. Relative wages
(nonproduction / production workers)

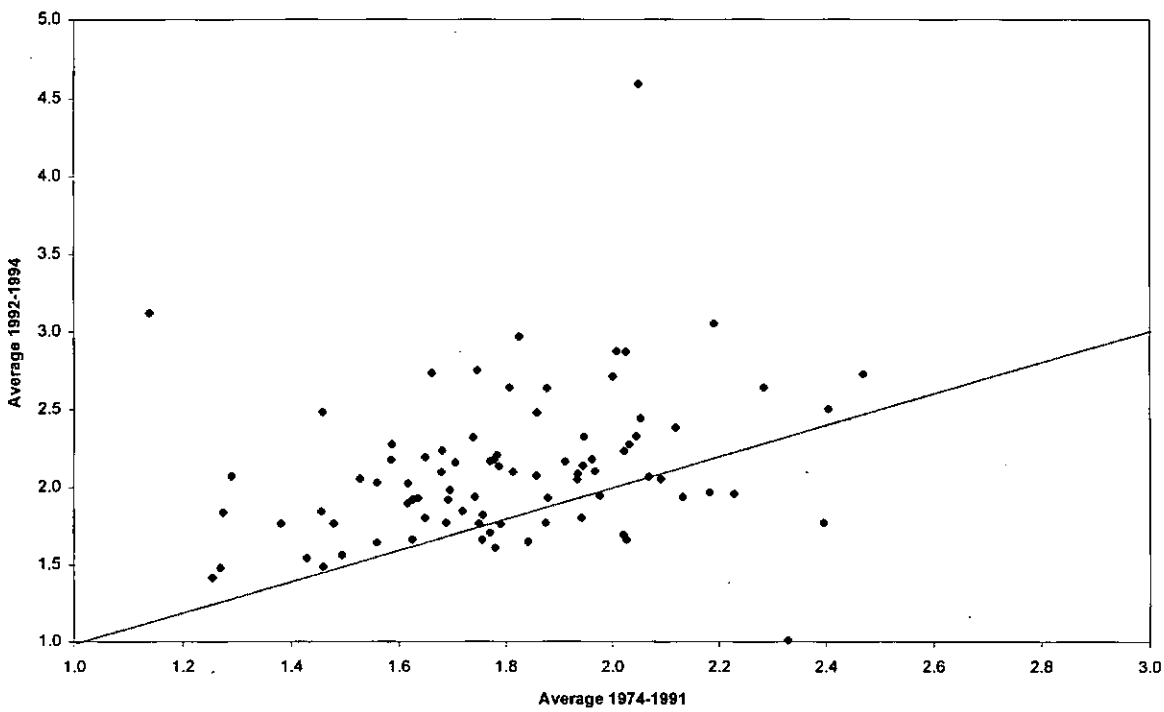
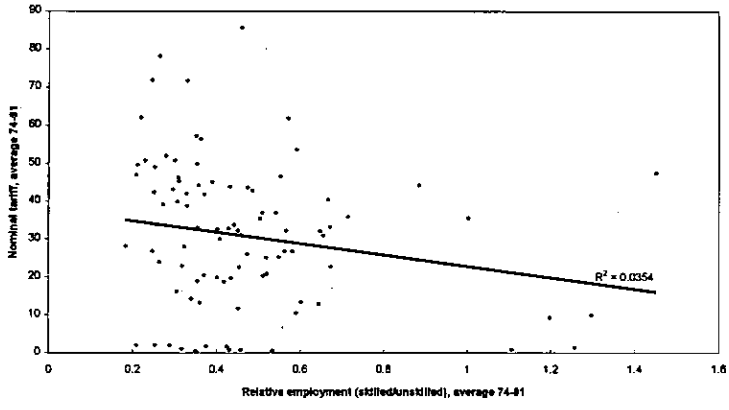
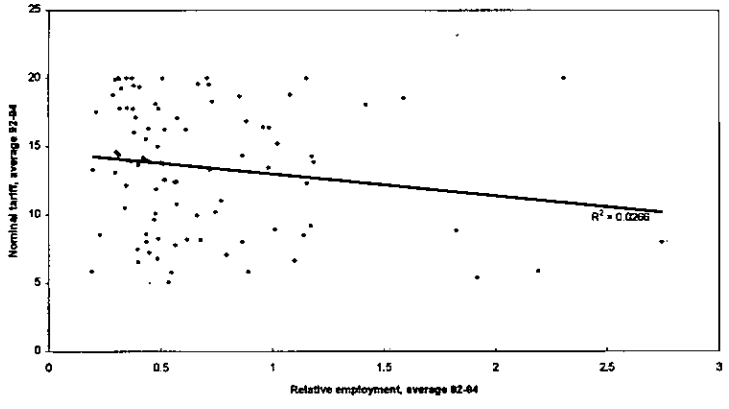


Figure 8

A. Relative employment and nominal tariff during the pre-reform period



B. Relative employment and nominal tariff during the post-reform period



C. Relative employment in 1991 and change in nominal tariff

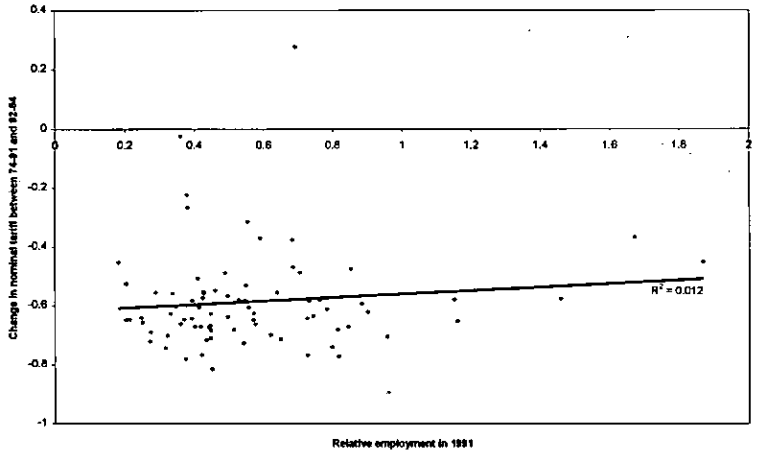


Table A1

Employment and Wage-Bill Shares by Educational Category, 1976-1996

	Employment share	Wage-bill share
1976	13.4	33.2
1981	15.7	29.7
1986	19.5	37.6
1991	23.7	41.2
1996	26.4	49.2

Workers with 12 or more years of schooling

Employment and Wage-Bill Shares by Occupational Category in the Manufacturing Sector, 1974-1994

	Employment share	Wage-bill share
1974	24.7	42.5
1981	27.3	41.3
1986	30.5	43.4
1991	33.3	48.5
1994	37.6	57.7

Nonproduction workers

Table A2
Employment Shares

Sector	Skilled* employment		Unskilled** employment	
	pre	post	pre	post
Manufacturing	17.60	16.55	32.33	30.92
Electricity and gas	1.44	1.40	0.99	0.84
Construction	3.47	3.38	7.11	7.19
Retail, restaurants and hotels	12.13	14.38	21.25	23.21
Transportation and Communications	4.47	4.44	7.68	7.82
Financial services	14.50	15.42	7.18	7.66
Personal and Gubernamental services	44.41	42.30	21.88	20.70
Other	1.98	2.13	1.58	1.66
Total urban	100.0	100.0	100.0	100.0

* 12 or more years of schooling

** Less than 12 years of schooling

Pre-reform: 1976-1991; post-reform: 1992-1996.

Source: NHS